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Ferro- and Antiferroelectric Substances

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7 Layer-structure oxides

7A Pure compounds of simple type

Nr. 7A-1 Bi_3TiNbO_9

1a Dielectric anomaly associated with a phase transition was reported by ISMAILZADE in 1960. *60I1*

b

phase	II	I
state		P[a])
crystal system	orthorhombic[b])	tetragonal[b])
space group	Fmm2-C_{2v}^{18}	I4/mmm-D_{4h}^{17}
Θ*	900 ··· 950 °C[b])	

[a]) *60I1*
[b]) *62S17*

$\varrho = 6.4 \cdot 10^3$ kg m^{-3}. *62S17*
$a = 5.40$ Å, $b = 5.44$ Å, $c = 25.1$ Å at RT.

4 Temperature dependence of lattice parameters: Fig. 868.
Linear thermal expansion: Fig. 869.

5a Dielectric constant: Fig. 870.
$\varkappa \approx 100$ at RT. *61S11*
The dielectric constant was not measured in the vicinity of the transition point because of high conductivity. Extrapolation of the Curie temperatures of the solid solution system obtained by the dielectric measurements indicates a transition temperature between 900° and 950 °C for Bi_3TiNbO_9.

Nr. 7A-2 Bi_3TiTaO_9

1a Phase transition similar to that of Bi_3TiNbO_9 was reported by SUBBARAO in 1962. *62S17*

b

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
space group	Fmm2-C_{2v}^{18}	I4/mmm-D_{4h}^{17}
Θ	870 °C	

62S17

$\varrho = 8.5 \cdot 10^3$ kg m^{-3}.
$a = 5.39$ Å, $b/a = 1.007$, $c = 25.1$ Å at RT.

4 Linear thermal expansion: see Fig. 869.

5a Dielectric constant: $\varkappa \approx 140$ at RT. *62S17*

Nr. 7A-3 $CaBi_2Nb_2O_9$

1a Dielectric anomaly associated with a phase transition was discovered by ISMAILZADE in 1960. *60I1*

b

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
space group	Fmm2-C_{2v}^{18}	I4/mmm-D_{4h}^{17}
Θ	625 °C	

60I1

$\varrho = 5.0 \cdot 10^3$ kg m^{-3}.
$a = 5.39$ Å, $b/a = 1.006$, $c = 25.15$ Å at RT. *62S17*

4 Temperature dependence of lattice parameters: Tab. 104.

5a Dielectric constant: Fig. 871. $\varkappa \approx 80$ at RT. *62S17*

* According to [*60I1*] Θ is 600 ··· 650 °C.

Tab. 104. Temperature dependence of the lattice parameters of $CaBi_2Nb_2O_9$ and $CaBi_2Ta_2O_9$ *[60I1]*

T	20	100	150	200	250	300	350	400	°C
				$CaBi_2Nb_2O_9$					
a	5.442	—	5.453	—	5.458	—	5.465	—	Å
b	5.482_5	—	5.484	—	5.487	—	5.491	—	Å
c	24.920	—	24.955	—	24.990	—	25.035	—	Å
b/a	1.0075	—	1.0056	—	1.005_3	—	1.0047	—	
V	743.5	—	746.0	—	748.5	—	751.0	—	Å³
				$CaBi_2Ta_2O_9$					
a	5.435	5.438	—	5.444	—	5.452	—	5.464	Å
b	5.468_5	5.471	—	5.475_6	—	5.479	—	5.482_6	Å
c	24.970	24.980	—	25.015	—	25.040	—	25.060	Å
b/a	1.006	1.006	—	1.005_8	—	1.005	—	1.003_5	
V	742.0	743.2	—	745.6	—	748.0	—	750.6	Å³

T	450	500	550	575	600	650	700	°C
				$CaBi_2Nb_2O_9$				
a	5.480	5.485	5.488_3	5.495_5	—	5.502_5	5.504	Å
b	5.496_7	5.501_3	5.502_5	5.503_7	—	5.502_5	5.504	Å
c	25.070	25.080	25.090	25.105	—	25.125	25.140	Å
b/a	1.0036	1.0029	1.0025	1.0015	—	1.000	1.000	
V	755.0	756.8	758.0	759.3	—	760.7	761.6	Å³
				$CaBi_2Ta_2O_9$				
a	—	5.470	5.473	—	5.479	5.484	—	Å
b	—	5.483_7	5.484	—	5.479	5.484	—	Å
c	—	25.070	25.083	—	25.085	25.105	—	Å
b/a	—	1.002_5	1.002_4	—	1.000	1.000	—	
V	—	751.9	752.8	—	730.0	755.0	—	Å³

Nr. 7A-4 $CaBi_2Ta_2O_9$

1a	Dielectric anomaly associated with a phase transition was discovered by Ismailzade in 1960.	*60I1*
b	see table below	*60I1*
	$\varrho = 7.5 \cdot 10^3$ kg m^{-3}.	*60I1*
	$a = 5.428$ Å, $b/a = 1.006$, $c = 24.90$ Å at RT.	*61S11*
4	Temperature dependence of lattice parameter: see Tab. 104.	
5a	Dielectric constant: Fig. 872.	

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
space group	Fmm2-C_{2v}^{18}	I4/mmm-D_{4h}^{17}
Θ	575 °C	

Nr. 7A-5 $SrBi_2Nb_2O_9$

1a	Dielectric anomaly associated with a phase transition was discovered by Smolenskii in 1961.	*61S11*
b	see table below	*61S11* a)*62S17*
	$\varrho = 6.9 \cdot 10^3$ kg m^{-3} a).	
	$a = 5.506$ Å, $b/a = 1.000$, $c = 25.05$ Å at RT.	*62S15*
5a	Dielectric constant: Fig. 873. $\varkappa \cong 190$ at RT. $\varkappa = C/(T - \Theta_p)$, where $C = 0.55 \cdot 10^5$ °C, $\Theta_p = 390$ °C.	*62S17*
7a	Piezoelectricity: $d_{33} = 1.0 \cdot 10^{-11}$ C N^{-1}.	*62S17*

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
Θ	420 440a) °C	

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Nr. 7A-6 $SrBi_2Ta_2O_9$

1a Ferroelectricity in $SrBi_2Ta_2O_9$ was reported by Smolenskii in 1961. *61S11*

b *61S11*

phase	II	I
state	F	P
crystal system	orthorhombic	tetragonal
Θ	310 °C	

$\varrho = 7.5 \cdot 10^3$ kg m^{-3}. *61S11*
$a = 5.512$ Å, $b/a = 1.000$, $c = 25.00$ Å at RT. *62S15*

5a Dielectric constant: Fig. 874. $\varkappa \cong 180$ at RT. *62S17*
$\varkappa = C/(T - \Theta_p)$, $C = 2.0 \cdot 10^6$ °C, $\Theta_p = 190$ °C. *62S17*

c Spontaneous polarization: $P_s = 5.8 \cdot 10^{-2}$ C m^{-2} at 25 °C. *62S17*

7a Piezoelectric constant: $d_{33} = 2.3 \cdot 10^{-11}$ C N^{-1}. *62S17*

Nr. 7A-7 $BaBi_2Nb_2O_9$

1a Dielectric anomaly associated with a phase transition was discovered by Smolenskii in 1961. *61S11*

b

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
Θ	210 °C 200[a]) °C	

61S11
[a])*62S17*

$\varrho = 6.3 \cdot 10^3$ kg m^{-3}.
$a = 5.554$ Å, $b/a = 1.000$, $c = 25.60$ Å at RT. *62S15*

5a Dielectric constant: Fig. 875. $\varkappa = 280$ at RT. *62S17*

Nr. 7A-8 $BaBi_2Ta_2O_9$

1a Dielectric anomaly associated with a phase transition was discovered by Smolenskii in 1961. *61S11*

b

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
Θ	110[a]) °C	

61S11
[a])*62S17*

According to [*61S11*] Θ is 70 °C. *61S11*
$\varrho = 8.4 \cdot 10^3$ kg m^{-3}.
$a = 5.556$ Å, $b/a = 1.000$, $c = 25.50$ Å at RT. *62S15*

5a Dielectric constant: Fig. 876. $\varkappa = 400$ at RT. *62S17*

Nr. 7A-9 $PbBi_2Nb_2O_9$

1a Dielectric anomaly associated with a phase transition in $PbBi_2Nb_2O_9$ was reported by Smolenskii in 1959. *59S8*

b

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
Θ	526 °C 550[a]) °C	

59S8
[a])*61S15*

$\varrho = 7.6 \cdot 10^3$ kg m^{-3}.
$a = 5.488$ Å, $b/a = 1.002$, $c = 25.55$ Å at RT. *62S15*

3 Crystal structure: Fig. 877.

4 Temperature dependence of lattice parameters: Fig. 878.

5a Dielectric constant: Fig. 879. $\varkappa = 170$ at RT. *62S17*
$\varkappa = C/(T - \Theta_p)$, $C = 1.3 \cdot 10^5$ °K, $\Theta_p = 510$ °C.

7a Piezoelectric constant: $d_{33} = 1.5 \cdot 10^{-11}$ C N^{-1}. *62S17*

Nr. 7A-10 $PbBi_2Ta_2O_9$

1a	Ferroelectricity was reported by SUBBARAO[a]) and SMOLENSKII[b]) independently in 1961.	a)61S15 b)61S11
b	phase: II / I; state: F / P; crystal system: orthorhombic / tetragonal	61S15
	Θ: 430 °C	61S11
	$\varrho = 9.0 \cdot 10^3$ kg m^{-3}. $a = 5.496$ Å, $b/a = 1.000$, $c = 25.40$ Å at RT.	62S15
5a	Dielectric constant: Fig. 880. $\varkappa = 180$ at RT. $\varkappa = C/(T - \Theta_p)$, $C = 3.7 \cdot 10^4$ °C, $\Theta_p = 325$ °C.	62S17
7a	Piezoelectric constant: $d_{33} = 5 \cdot 10^{-12}$ C N^{-1}.	62S17

phase	II	I
state	F	P
crystal system	orthorhombic	tetragonal
Θ	430 °C	

Nr. 7A-11 $Bi_4Ti_3O_{12}$

1a	Ferroelectricity in $Bi_4Ti_3O_{12}$ was reported by VAN UITERT et al. in 1961.	61V2
b	phase / state / crystal system / Θ (see table below)	61V2 a)67C6
	Unit cell is very nearly orthorhombic with the lattice parameters: $a_{orth} = 5.411$ Å, $b_{orth} = 5.448$ Å, $c_{orth} = 32.85$ Å at RT. Relations between crystallographic axes: Fig. 881. P_s lies in a direction tilted at approximately 7° (or less) from the major crystal surface in a plane parallel to the pseudo-orthorhombic $b - c$ plane.	67C6
2a	Crystal growth: Cooling method from melt consisting of 100 Bi_2O_3 and 5 TiO_2 (weight ratio).	61V2
3	Crystal structure: Fig. 882.	
4	Temperature dependence of lattice parameter: Fig. 883. Thermal expansion: Fig. 884.	
5a	Dielectric constant: Fig. 885.	
c	P_s and E_c: Fig. 886, 887. TAMBOVTSEV et al. measured P_s and E_c by applying a field parallel to the c_{orth} direction, $P_s = 1.99 \cdot 10^{-2}$ C m^{-2}, $E_c = 1.13 \cdot 10^4$ V m^{-1}. According to [67C6], the spontaneous polarization lies in the pseudo-orthorhombic (100) plane and has a value larger than $30 \cdot 10^{-2}$ C m^{-2}.	63T1 67C6
7	Piezoelectric constant: $d_{33} = 2.0 \cdot 10^{-11}$ C N^{-1}.	61S17
10	Conductivity: see	64P3
14a	Domain structure: see Domains have been observed by polarized light.	64P3 66C7
b	Switching: Fig. 888, 889. See also Fig. 892, Tab. 105 and:	66P6
17	Twinning structure: see	64P3

phase	II	I
state	F	P
crystal system	monoclinic[a])* (pseudo-orthorhombic)	tetragonal
Θ	675 °C	

Nr. 7A-12 $BaBi_3Ti_2NbO_{12}$

1a	Dielectric anomaly associated with a phase transition was reported by SUBBARAO in 1961.	61S15
b	phase / state / crystal system / Θ (see table below) $a = 3.874$ Å, $c = 33.70$ Å at RT.	61S15

phase	II	I
state		P
crystal system	pseudo-tetragonal	tetragonal
Θ	270 °C	

Nr. 7A-13 $PbBi_3Ti_2NbO_{12}$

1a	Dielectric anomaly associated with a phase transition was reported by SUBBARAO in 1961.	61S15

* Point group is m.

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1b

phase	II	I
state		P
crystal system	pseudo-tetragonal	tetragonal
Θ	290 °C	

61S15

$a = 3.687$ Å, $c = 33.55$ Å at RT. *61S15*

Nr. 7A-14 $BaBi_4Ti_4O_{15}$

1a Dielectric anomaly associated with a phase transition was reported independently by Subbarao[a]) and by Smolenskii[b]) in 1961. Ferroelectric activity was reported independently by Fang et al. in 1961[c]). [a])*61S15* [b])*61S11* [c])*61F7*

b

phase	II	I
state	F	P
crystal system	orthorhombic (or pseudo-orthorhombic)	tetragonal
Θ	375 °C 395[a]) °C	

61F7; [a])*61S15*

$\varrho = 5.7 \cdot 10^3$ kg m^{-3}.
$a = 5.461$ Å, $b/a = 1.000$, $c = 41.85$ Å at RT. *62S15*

3 Crystal structure: Fig. 890.

5a Dielectric constant: Fig. 891. $\varkappa = 150$ at RT.
$\varkappa = C/(T - \Theta_p)$, $C = 2.5 \cdot 10^5$ °K, $\Theta_p = 335$ °C. *61S15*

7a Piezoelectric constant: $d_{33} = 2.3 \cdot 10^{-11}$ C N^{-1}. *62S17*

14b Switching: Fig. 892; Tab. 105.

Tab. 105. $BaBi_4Ti_4O_{15}$, $Ba_2Bi_4Ti_5O_{18}$, $Bi_4Ti_3O_{12}$, $BaTiO_3$ (for comparison). Switching parameters in comparison with those of $BaTiO_3$ [*62F1*]. $t_s = t_\infty \exp(+\alpha/E)$, t_s = switching time

	$BaTiO_3$	$Bi_4Ti_3O_{12}$	$BaBi_4Ti_4O_{15}$	$Ba_2Bi_4Ti_5O_{18}$	
α	6.1	41	23	76	10^5 V m^{-1}
t_∞	0.4	10^{-2}	1.5	10^{-3}	μ sec

Nr. 7A-15 $PbBi_4Ti_4O_{15}$

1a Dielectric anomaly associated with a phase transition was reported by Subbarao in 1961. *61S15*

b

phase	II	I
state		P
crystal system	orthorhombic (possibly)	tetragonal
Θ	570 °C	

61S15

$\varrho = 6.6 \cdot 10^{-3}$ kg m^{-3}.
$a = 5.437$ Å, $b/a = 1.000$, $c = 41.35$ Å at RT. *62S15*

5a Dielectric constant: Fig. 893. $\varkappa = 220$ at RT. *61S15*
$\varkappa = C/(T - \Theta_p)$, $C = 1.4 \cdot 10^5$ °C, $\Theta_p = 552$ °C. *62S17*

7a Piezoelectric constant: $d_{33} = 2.3 \cdot 10^{-11}$ C N^{-1}. *62S17*

Nr. 7A-16 $SrBi_4Ti_4O_{15}$

1a Dielectric anomaly associated with a phase transition was reported by Subbarao in 1961. *61S15*

b

phase	II	I
state		P
crystal system	orthorhombic (possibly)	tetragonal
Θ	530 °C	

61S15

$\varrho = 5.2 \cdot 10^3$ kg m^{-3}. *62S17*
$a = 5.428$ Å, $b/a = 1.000$, $c = 40.95$ Å at RT. *62S15*

5a Dielectric constant: Fig. 894. $\varkappa = 190$ at RT.
$\varkappa = C/(T - \Theta_p)$, $C = 0.68 \cdot 10^5$ °C, $\Theta_p = 485$ °C. *62S17*

7a Piezoelectric constant: $d_{33} = 1.5 \cdot 10^{-11}$ C N^{-1}. *62S17*

Nr. 7A-17 $CaBi_4Ti_4O_{15}$

1a	$CaBi_4Ti_4O_{15}$ was investigated by SUBBARAO in 1962. No dielectric anomaly has been detected.	62S17
b	Orthorhombic: $a = 5.418$ Å, $b/a = 1.002$, $c = 40.75$ Å at RT. $\varrho = 4.7 \cdot 10^3$ kg m^{-3}.	62S15
5a	Dielectric constant: Fig. 895. $\varkappa = 120$ at RT.	61S11

Nr. 7A-18 $Bi_5Ti_3GaO_{15}$

1a	$Bi_5Ti_3GaO_{15}$ was investigated by SUBBARAO in 1962. No dielectric anomaly has been detected.	62S17
b	Orthorhombic: $a = 5.408$ Å, $b/a = 1.006$, $c = 41.05$ Å at RT. $\varrho = 7.3 \cdot 10^3$ kg m^{-3}.	62S15
5a	Dielectric constant: $\varkappa = 150$ at RT.	62S17

Nr. 7A-19 $Ba_2Bi_4Ti_5O_{18}$

1a Ferroelectric activity of $Ba_2Bi_4Ti_5O_{18}$ was observed by AURIVILLIUS in 1962. 62A5

b

phase	II	I
state	F	P
crystal system	orthorhombic	tetragonal
Θ	325 °C	

62A5

$a = 5.527$ Å, $b = 5.514$ Å, $c = 50.37$ Å at RT. 63I5

3	Crystal structure: Fig. 896; Tab. 106.	
4	Temperature dependence of lattice parameter: Fig. 897.	
5a	Dielectric constant: Fig. 898. $\varkappa' = 360$, $\varkappa'' = 22$ at RT.	62A5
c	Remanent polarization: $P_r = 2 \cdot 10^{-3}$ C m^{-2} at RT. Coercive field: $E_c = 1.0 \cdot 10^6$ V m^{-1} at RT.	62A5
14b	Switching: see Fig. 892; Tab. 105.	

Tab. 106. $Ba_2Bi_4Ti_5O_{18}$. Fractional coordinates of atoms [62A5]. Space group of I4/mmm was assumed.

I4/mmm	(0, 0, 0; 1/2, 1/2, 1/2)+	
4 Bi in 4(e):	±0, 0, z:	z = 0.2255
4 (Bi, Ba) in 4(e):		z = 0.0420
4 (Bi, Ba) in 4(e):		z = 0.1300
2 Ti in 2(b):	±0, 0, 1/2	
4 Ti in 4(e):		z = 0.3370
4 Ti in 4(e):		z = 0.4185
4 O in 4(c):	0, 1/2, 0; 1/2, 0, 0	
4 O in 4(d):	0, 1/2, 1/4; 1/2, 0, 1/4	
4 O in 4(e):		z = 0.2962
4 O in 4(e):		z = 0.3378
4 O in 4(e):		z = 0.4593
8 O in 8(g):	±(0, 1/2, z; 1/2, 0, z)	z = 0.0815
8 O in 8(g):		z = 0.1630

Nr. 7A-20 $Pb_2Bi_4Ti_5O_{18}$

1a Ferroelectric activity in $Pb_2Bi_4Ti_5O_{18}$ was observed by SUBBARAO in 1962. 62S17

b

phase	II	I
state	F	P
crystal system	orthorhombic (possibly)	tetragonal
Θ	310 °C	

62S17

$\varrho = 6.6 \cdot 10^3$ kg m^{-3}.

$a = 5.461$ Å, $b/a = 1.000$, $c = 49.70$ Å at RT. 62S15

5a	Dielectric constant: Fig. 899. $\varkappa = 400$ at RT. $\varkappa = C/(T - \Theta_p)$, $C = 4.1 \cdot 10^5$ °K, $\Theta_p = 280$ °C.	*62S17*
c	Spontaneous polarization: $P_s = 6 \cdot 10^{-2}$ C m^{-2} at 235 °C.	*62S17*
7a	Piezoelectric constant: $d_{33} = 2.5 \cdot 10^{-12}$ C N^{-1}.	*62S17*

Nr. 7A-21 $Sr_2Bi_4Ti_5O_{18}$

1a	Ferroelectric activity in $Sr_2Bi_4Ti_5O_{18}$ was observed by Subbarao in 1962.	*62S17*
b	phase: II, I; state: F, P; crystal system: orthorhombic (possibly), tetragonal	
	Θ 285 °C	*62S17*
	$\varrho = 5.3 \cdot 10^3$ kg m^{-3}. $a = 5.461$ Å, $b/a = 1.000$, $c = 48.80$ Å at RT.	*62S15*
5a	Dielectric constant: Fig. 900. $\varkappa = 280$ at RT. $\varkappa = C/(T - \Theta_p)$, $C = 0.47 \cdot 10^5$ °K, $\Theta_p = 255$ °C.	*62S17*
c	Spontaneous polarization: $P_s = 3.5 \cdot 10^{-2}$ C m^{-2} at 255 °C.	*62S17*
7a	Piezoelectric constant: $d_{33} = 2.5 \cdot 10^{-12}$ C N^{-1}.	*62S17*

phase	II	I
state	F	P
crystal system	orthorhombic (possibly)	tetragonal
Θ	285 °C	

Nr. 7A-22 $Bi_2Ti_4O_{11}$

1a	Dielectric anomaly associated with a phase transition was observed in $Bi_2Ti_4O_{11}$ by Subbarao in 1962.	*62S16*
b		*65J4*
	Θ 250 a), 1200 a) °C	a) *62S16*
	$\varrho = (6.12 \pm 0.02) \cdot 10^3$ kg m^{-3}.	*65J4*
	$a = (14.612 \pm 0.006)$ Å, $b = (3.799 \pm 0.004)$ Å, $c = (14.946 \pm 0.006)$ Å, $\beta = (93.13 \pm 0.01)°$ at RT.	*65J4*
3	Crystal structure: $Z = 2$ in phase II. $Z = 4$ in phase III. Fig. 901, 902; Tab. 107.	*65J4*
4	Thermal expansion: Fig. 903.	
5a	Dielectric constant: Fig. 904.	
c	No hysteresis loops could be obtained between 25 °C and 290 °C.	*62S16*

phase	III		II		I
crystal system	monoclinic		monoclinic		
space group	C2/c-C_{2h}^6		C2/m-C_{2h}^{3} *		
Θ		250 a)		1200 a)	°C

Tab. 107. $Bi_2Ti_4O_{11}$. Atomic parameters at RT [*65J4*]

Atom	x	y	z
O(1)	0.0	0.262 ± 0.012	0.250
O(2)	0.1828 ± 0.0024	0.246 ± 0.007	0.2207 ± 0.0024
O(3)	0.1408 ± 0.0024	0.256 ± 0.007	0.0338 ± 0.0024
O(4)	0.0814 ± 0.0024	0.760 ± 0.007	0.1259 ± 0.0024
O(5)	0.2662 ± 0.0024	0.747 ± 0.007	0.0880 ± 0.0024
O(6)	0.0546 ± 0.0024	0.770 ± 0.007	0.9221 ± 0.0024
Ti(1)	0.0530 ± 0.0006	0.250 ± 0.002	0.1406 ± 0.0006
Ti(2)	0.1461 ± 0.0006	0.759 ± 0.002	0.0162 ± 0.0006
Bi	0.3211 ± 0.00015	0.1747 ± 0.0005	0.1798 ± 0.00015

Thermal parameter $B = 0.33$ Å^2 for all atoms. Coordinates and standard deviations in cell fractions.

7B Complex compounds and solid solutions

Nr. 7B-1 $Bi_{2-x}Me_x^{2+}Ti_{1-x}Nb_{1+x}O_9$ (Me^{2+} = Ba, Sr, Pb)

1b	Lattice parameter: Fig. 905. Transition temperature: Fig. 906.
5	Dielectric constant: Fig. 907.

Nr. 7B-2 $Bi_{4-x}Me_x^{2+}Ti_{3-x}Nb_xO_{12}$ (Me^{2+} = Ba, Sr, Pb)

1b	Lattice parameter: Fig. 908. Transition temperature: Fig. 909.
5	Dielectric constant: Fig. 910.

* The unit cell of phase II has about half the volume of the unit cell of phase III.

Nr. 7B-3 $Na_{0.5}Bi_{4.5}Ti_4O_{15}$

1a Dielectric anomaly associated with a phase transition was reported by SUBBARAO in 1962. *62S17*

b

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
Θ	650 °C	

62S17

$\varrho = 6.3 \cdot 10^3$ kg m^{-3}.
$a = 5.427$ Å, $b/a = 1.006$, $c = 40.65$ Å at RT. *62S15*

5a Dielectric constant: Fig. 911. $\varkappa = 200$ at RT.
$\varkappa = C/(T - \Theta_p)$, $C = 0.79 \cdot 10^5$ °K, $\Theta_p = 610$ °C. *62S17*

7a Piezoelectric constant: $d_{33} = 1.0 \cdot 10^{-11}$ C N^{-1}. *62S17*

Nr. 7B-4 $K_{0.5}Bi_{4.5}Ti_4O_{15}$

1a Dielectric anomaly associated with a phase transition was reported by SUBBARAO in 1962. *62S17*

b

phase	II	I
state		P
crystal system	orthorhombic	tetragonal
Θ	550 °C	

62S17

$\varrho = 6.7 \cdot 10^3$ kg m^{-3}.
$a = 5.440$ Å, $b/a = 1.004$, $c = 41.15$ Å at RT. *62S15*

5a Dielectric constant: Fig. 912. $\varkappa = 140$ at RT.
$\varkappa = C/(T - \Theta_p)$, $C = 0.74 \cdot 10^5$ °K, $\Theta_p = 515$ °C. *62S17*

7a Piezoelectric constant: $d_{33} = 1.0 \cdot 10^{-11}$ C N^{-1}. *62S17*

Nr. 7B-5 $(Pb_{1-x}Ba_x)Bi_2Nb_2O_9$ and $(Pb_{1-x}Sr_x)Bi_2Nb_2O_9$

1b Transition temperature: Fig. 913.
5 Dielectric constant: Fig. 914.

Nr. 7B-6 $(1\text{-}x)Bi_4Ti_3O_{12}$ - $xBaTiO_3$

5 Transition temperature: Fig. 915.

Nr. 7B-7 $Bi_{4+x}Pb_{1-x}Ti_{4-x}Ga_xO_{15}$

1a Another formula for this solid solution is $(1 - x)PbBi_4Ti_4O_{15} \cdot xBi_5Ti_3GaO_{15}$. Properties of this solid solution were studied by SUBBARAO in 1962. *62S17*

b $x = 0.25$: *62S17*

phase	II	I
state		P
crystal system	orthorhombic (pseudo-tetragonal)	tetragonal
Θ	600 °C	

Pseudo-tetragonal cell parameter: $a = 3.842$ Å, $c = 41.40$ Å at RT.
Dielectric constant: $\varkappa = 180$ at RT; $\varkappa = 3035$ at Θ.

$x = 0.5$: *62S17*

phase	II	I
state		P
crystal system	orthorhombic (pseudo-tetragonal)	tetragonal
Θ	620 °C	

Pseudo-tetragonal cell parameter: $a = 3.842$ Å, $c = 41.40$ Å at RT.
Dielectric constant: $\varkappa = 179$ at RT; $\varkappa = 1930$ at Θ.